# Management of Repair Parts In The Heavy Division: Is There A Better Way?



A Monograph
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## ABSTRACT

**MANAGEMENT OF REPAIR PARTS IN THE HEAVY DIVISION: IS THERE A BETTER WAY?** by MAJ Glenn H. Takemoto, USA, 51 pages.

The Army expends billions of dollars in resources to provide the right repair parts at the right place and time. Despite this enormous expenditure, the Army's sustainment system fails to accomplish this task. The subject of this monograph is the search for a better way to provide ground equipment repair parts in the heavy division in order to generate and sustain combat power.

This monograph first surveys the results of evaluations that focused on the repair parts management system. Second, it studies the current repair parts management system to identify the sources of the problem. Then it explores the areas of operations research and the private sector for ways to resolve the problem. The monograph analyzes and evaluates these possible alternatives to improve repair parts management in the heavy division.

The monograph concludes that the current system can and should be improved. The bottom-driven repair parts management system does not support the generation and sustainment of combat power. The current system does not meet the needs of its customers. The basis for this failure is an inability to forecast accurately the demand for repair parts and efficiently utilize the supply and distribution resources. Further exacerbating these shortfalls is the reactive versus proactive design of the current system.

The recommendations call for adopting operations research alternatives in association with a centralized, top-down approach to repair parts management similar to the private sector. A specific recommendation calls for a forecasting model at the DMMC that establishes causal relationships between demand for repair parts and equipment utilization. Such a system will allow more accurate forecast of repair parts demands. This forecast then enables the repair parts management system to more efficiently utilize and integrate the supply and distribution systems and lower inventory levels while simultaneously satisfying the needs of the customer.

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# I. INTRODUCTION

The sole measurement of successful sustainment has always been the generation of combat power at the decisive time and place.[1]

FM 100-5

The means to generate combat power rests heavily on the sustainment system's ability to keep combat systems operational. The sustainment system must rapidly repair combat systems disabled by battle damage or breakdown and return them to battle. To accomplish this, the sustainment system must anticipate the needs of the supported unit and have the right repair parts, at the right time and place.

Although this may sound like a simple task, it is very difficult to achieve. The resources dedicated to this task are significant. For a U.S. Army heavy division, the dollar value of the direct support level stocks of repair parts is $31,596,857 for 8,238 different types of parts. The total volume is 63,335 cubic feet, and the total weight is 1,040 tons.[2] In spite of these resources, numerous reports on the repair parts management system conclude that the sustainment system fails to provide the right repair parts at the right time and place.[3]

The heavy division must have an efficient and effective repair parts management system that

economically supports training, immediate deployment, and commitment to battle. An inefficient sustainment system wastes resources that are better utilized elsewhere and denies the availability of combat systems for training. In peacetime the costs are training opportunities and readiness, but in war the inability to generate and sustain combat power may cost lives and battles. Is there a better way to manage repair parts in the heavy division?

This monograph seeks a better way to anticipate and meet the heavy division's need for ground equipment repair parts. The intent is to find ways to improve the sustainment system's ability to generate and sustain combat power at the decisive time and place.

This monograph first studies the current repair parts management system in the heavy division to establish that a problem exists. Second, it explores the areas of operations research and the private sector to look for ways to resolve the problem. The next section evaluates these ways for improving the repair parts management of the heavy division. The final section presents the summary and recommendations.

## II. OVERVIEW OF CURRENT REPAIR PARTS MANAGEMENT IN THE HEAVY DIVISION

### EFFECTIVENESS OF THE CURRENT SYSTEM

The effectiveness of the current repair parts management system has been the subject of numerous studies and evaluations over the past decade. These studies and evaluations have been consistent in concluding that the repair parts management system is inefficient, ineffective, and, more importantly, does not support the Army's ability to generate combat power. At the root of the problem is the system's inability to accurately forecast the type and quantity of repair parts the division will need. Consequently, units do not have required repair parts but have on hand excess, unneeded stock. The purchase and storage of this excess materiel wastes funds and inventory space.

On 30 August 1981, the Department of the Army, Deputy Chief of Staff for Logistics (DCSLOG) published a report on the repair parts management system. This report considered the results of seventeen reports from the General Accounting Office, Army Audit Agency, Inspector General, and the Human Engineering Laboratory. The DCSLOG report concluded that the

repair parts management system was inefficient because it relied too heavily on the PLL clerk and his forecast of demand. The PLL clerk was unable to provide an accurate forecast of demand because of the design of his forecasting system. Since the PLL was the foundation of the repair parts system, the inaccurate forecast of demand negatively affected the entire system.[1]

Further evidence of problems with the repair parts management system appears in several studies by the Army Materiel Studies and Analysis Agency (AMSAA).[2] For example, a study in 1986 found that units at Fort Hood and Fort Campbell stocked only 40% of the parts demanded. Similarly, an evaluation from 1988-89 found Fort Rucker units stocked only 47% of the parts demanded. These results fall short of the Army's standard of having in stock at least 75% of the parts requested by customer units.[3]

In 1991 the U.S. Army Quartermaster School published a draft concept for the Battlefield Spares System with similar conclusions about the ongoing problems with the repair parts management system:

> Given the poor performance and high cost of the current PLL/ASL system and the limited resources available to the Army, a more efficient, responsive and cost effective means of providing repair parts across the operational continuum is required.[4]

> Recent field exercise data (1988-1989) examined by the U.S. Army Materiel Systems Analysis Activity has indicated marginal performance rates for ASL and PLL items. Reports....have revealed that current supply policies and procedures are inefficient and ineffective. These conditions have contributed to the generation of excess stocks. ASL/PLL turbulence is one of the primary factors in this condition...[5]

Recently, the Desert Storm Special Study Team identified these same shortfalls as a problem in the heavy division's repair parts management system.[6]

What is preventing the sustainment system from efficiently and effectively supporting the generation of combat power? To answer to this question, we must look at how the repair parts management system currently operates. This management system derives from the principles, policies, and procedures that govern maintenance and supply in the heavy division.

## PRINCIPLES AND REGULATORY GUIDANCE

The essence of the division's principles of maintenance lies in the concepts of "fix forward" and "remove and replace."[7] These concepts originate from the desire to provide continuous combat power to commanders by rapidly repairing weapon systems and other equipment and returning them to battle. In the heavy division, "fix forward" translates to performing the maintenance mission as far forward on the battlefield or as close to the breakdown site as

possible. "Remove and replace" is the preferred method of maintenance because it is easier and more expedient than trying to repair the damaged part. This system of maintenance is extremely dependent upon the availability of repair parts.

Army Regulation (AR) 750-1, Army Materiel Maintenance Policies, provides the maintenance policies that impact upon the management of repair parts in the heavy division. Policies in the regulation support, and are in concert with, the concepts of maintenance. For example, the regulation supports the concept of "remove and replace" by stating that a priority of the Army policy is to design weapons and equipment that maintenance personnel can fix by simple fault diagnosis and component repair. The regulation also supports the concept of "fix forward" because it emphasizes that the system of repair parts should support repairs being done on site, as far forward as possible, and by the lowest level capable of performing the repair.[8]

The heavy division has two levels of maintenance and supply, unit and direct support.[9] Unit level maintenance is the lowest level and forms the foundation of the maintenance system. Equipment operators and unit mechanics conduct unit level maintenance. In order to perform this maintenance,

units must maintain a stock of authorized repair parts on hand or on order. The Army refers to this unit level supply stockage as the Prescribed Load List (PLL).[10] The PLL is a list of repair parts a unit must have for its equipment operators and unit mechanics to perform maintenance. The stockage should be at a level capable of sustaining the unit for a specified period of time, usually fifteen days.[11] The units must also maintain their PLL records, submit replenishment requests, and conduct inventories of their stocks. The unit PLL section normally consists of one soldier who is responsible for determining and maintaining the inventory of repair parts for the unit.[12]

The PLL is made up of two categories of parts, mandatory and demand supported.[13] A mandatory parts list (MPL) from the Materiel Readiness Support Activity (MRSA) specifies the type and quantity of mandatory parts the PLL will stock.[14] Through computer modeling, the MRSA determines the parts a unit needs to support combat operations. The MPL also includes parts that are deemed essential but not supported by previous demand.

The second category of parts in the PLL is demand supported parts.[15] Unlike mandatory parts, the PLL

clerk determines the inventory of demand supported parts based on guidelines established in AR 710-2, Supply Policy Below the Wholesale Level, and Department of the Army Pamphlet (DA PAM) 710-2-1, Using Unit Supply System Manual Procedures. The guidance limits the PLL to 300 types of repair parts, which the unit must be capable of transporting with organic means.[16] The clerk must keep the PLL current in its reflection of the demands of his unit. He does this according to the following guidelines: to add a part, it must be authorized and have at least three demands within a control period of 180 days,[17] to retain a part, it must have at least one demand in a period of 180 days.[18] The number of demands also determines the quantity of each repair part in the PLL (i.e., the greater the demand the larger the quantity in the inventory).[19] The tables found in DA PAM 710-2-1 specify the PLL stockage level that the unit must have on hand based on the number of demands received.[20] When the PLL clerk determines a need for repair parts, he requisitions and receives these parts from the technical supply section of the unit, which comprises the second level of maintenance and supply in the heavy division.[21]

This second level of maintenance and supply is the direct support (DS) level. The maintenance direct support unit (DSU) performs this DS level maintenance on a dedicated "repair and return to the user" basis. In other words, equipment turned in for maintenance returns to its original owner.[22]

Similar to the PLL maintained by the unit level clerks, the technical supply section of the maintenance DSU is responsible for maintaining the division's Authorized Stockage List (ASL) of repair parts. The ASL is a list of parts the DSU must stock to meet the requirements of customer units and the direct support maintenance shops.[23] Army Regulation 710-2 and DA PAM 710-2-2, Supply Support Activity Supply System Manual Procedures, provide the procedural guidelines for the ASL. The regulation outlines policy and performance standards for the ASL while specific operating procedures are in the pamphlet. For DSUs that deploy with an ASL, AR 710-2 constrains the ASL to 5,000 lines; it further specifies that this quantity of repair parts should sustain the division for 30 days.[24]

While the DSU physically maintains the ASL, it is the Division Materiel Management Center (DMMC), more specifically its materiel section, that provides

guidance to the DSU and manages the ASL. The materiel section of the DMMC consists of senior logistics management personnel equipped with communications and Automatic Data Processing (ADP) support systems. This section is responsible for monitoring and making recommendations on the size and composition of unit PLLs and determining the size, location, and composition of the division's ASL.[25]

Aggregate demand history is the primary basis for ASL stockage. These demands originate from the supported unit PLLs and the DSU maintenance operations.[26] Like the PLL clerk, the DMMC must constantly monitor and update the ASL so it reflects the current needs of the units which depend on the repair parts. The DMMC uses the following guidelines: to add a part, there must be nine or more requests for the part within a 360-day period;[27] to retain a part on the ASL, there must be at least three requests for the part in the most recent 360-day period.[28] The division convenes a quarterly board to review and approve additions to and deletions from the ASL. Like the PLL, the ASL's stockage results from a simple extrapolation of demand history. This method of forecasting for both the PLL and the ASL has proven to be inefficient.[29]

The DMMC determines the composition of the ASL by adhering to four requirements. The ASL must: stock the parts listed in the mandatory parts list (MPL) portion of PLLs, furnish parts for initial provisioning, meet unit PLL requisitions, and support operational readiness float.[30]

Army Regulation 710-2 provides the DMMC with the performance standards for the ASL. The applicable standards are demand satisfaction and zero balance with dues-out. Demand satisfaction measures how well the ASL meets the demands of its customers. The Army's customer satisfaction standard for the ASL is 75%.[31] Zero balance with dues-out measures the number of ASL lines that are out of stock for which customer demand still exists. The Army standard is for the ASL to be out of stock on requested items only 8% of the time.[32]

In an effort to meet these performance standards, the DMMC uses one of its primary ADP systems, the Direct Support Unit Standard Supply System (DS4), to tabulate the history of repair parts demand in the division.[33] The DS4 system provides assistance to the units by tabulating their demand history and making recommendations for changes.[34] Unfortunately, a limiting factor of this system is its discrete handling

of the unit PLLs and the division's aggregated demand. To determine the composition of the unit's PLL, the system analyzes the unit's demand history but ignores the possible benefits of comparing and contrasting it to the collective history of the division's aggregated demand. This autonomous operation is characteristic of the independent ordering system discussed further in the operations research alternatives section.[35]

In summary, the principles and regulatory guidance for maintenance are consistent in their purpose of rapidly returning weapon systems to battle. However, the regulatory guidance for repair parts management is inefficient and ineffective because it establishes a system that hinders readiness and training, wastes resources, and ultimately fails to generate and sustain combat power.

The problem with the current repair parts management system in the heavy division is its inability to accurately forecast demand. The system relies almost exclusively on requests from customers as the impetus to provide repair parts.[36] As a result, the system is bottom driven and reactive in nature, instead of proactive. In contrast, a proactive system would provide the part to the customer in anticipation of the need. A proactive system would reduce the

response and repair time and thereby contribute to the generation of continuous combat power.

Reports and evaluations on the repair parts management system support this position and state that the heavy division and the Army would benefit from improvements in the forecasting of demand for repair parts and the management of repair parts.[37] Where can we look for assistance in developing these needed improvements? There are two sources readily available, the field of operations research and private industry.

## III. OPERATIONS RESEARCH ALTERNATIVES

Operations research is commonly known as the scientific approach to decision making.[1] Operations research can improve the efficiency and effectiveness of the repair parts management system. The way to this improvement is through inventory management. The means are accurate forecasting and utilization of a suitable ordering and distribution system.

### INVENTORY MANAGEMENT

Inventory management is more than a clerical and accounting function. It is a critical management function designed to place the right item at the right time and place.[2] Inventory management does this by

planning, operating, coordinating, and controlling the interactivity of the components of the support system.[3] The heavy division's inventory management system, like any other inventory management system, has two primary objectives: keep costs low by maintaining as small an inventory as possible and provide responsive service to the customer.[4]

These objectives can be and often are in conflict. Prompt customer service means providing every item on demand. Unfortunately, this level of responsiveness usually requires large and expensive inventories. Conversely, a small inventory decreases the possibility of having what the customer wants but costs less. Obviously, one goal of an inventory management system is to find the correct balance between a small inventory and customer satisfaction. The key to this is an accurate forecast of the customer's needs. An accurate forecast allows for an inventory that satisfies all of the customer's needs and avoids stocking unnecessary items.

## FORECASTING

Forecasting is the general way of estimating, calculating, and predicting the future.[5] In repair parts management the goal is to accurately predict the failure rate and subsequent demand for parts. This

prediction must be made early enough to account for the time it takes to order and ship the part to the required delivery site. The only way to ensure the conjunction of the right repair part, in the right quantity, at the right time and place, is through forecasting.

The four principles of forecasting are: forecasts are more accurate for larger groups of items; forecasts are more accurate for shorter periods of time; every forecast should include an estimate of error; and a forecast method should be tested before it is applied to a system.[6]

There are three essential steps in forecasting. These steps are gathering and preparing the data, making the forecast through an analysis process, e.g., with a quantitative model, and monitoring the forecast during testing and implementation.[7]

Statistical forecasts assume a relationship exists between the past and the future, i.e., the future is an extension of the past or the future will replicate the past. The nature of this relationship determines which forecasting approach is the most applicable to the problem.[8]

There are two general approaches to forecasting, qualitative and quantitative.[9] Human judgement is

the root of the qualitative approach. Qualitative predictions range from those based on expert opinions to those that are the result of random surveys. In a qualitative approach, the database of opinions provide the basis for the mathematical representation of their significance, e.g., 90% of soldiers dislike MREs. [10]

The quantitative approach uses mathematical techniques. These techniques take quantifiable intrinsic and extrinsic factors, analyze their relationship to the problem, then develop a statistical expression of this relationship, e.g., the mean time between engine failure is 200 hours.[11]

Practitioners of the quantitative approach consider intrinsic factors such as demand histories and historical trends to be facts that relate directly to the item studied. On the other hand, extrinsic factors such as miles driven and rounds fired require that a causal relationship exists between the item and the factor.[12]

Quantitative techniques should not be without human judgement. Human judgement must be brought to bear to discern where the past and the future diverge. Only the human mind can process a variety of non-quantifiable information and make qualitative judgements. Therefore, each decision or forecast

should be a combination of qualitative and quantitative analysis.[13]

The quantitative system of forecasting consists of a variety of mathematical techniques. The techniques available to conduct quantitative analysis and forecasting range from simple averaging to highly complex mathematical processes.[14]

The mechanical or naive approach is an arbitrary method that uses simplistic projections of historical data. This approach assumes that the future is merely an extension of the past.[15] This is an unsophisticated and inaccurate method of extrapolation that is popular because of its simplicity and ease of understanding.[16] The Army's PLL and ASL system uses this approach.[17]

A moving average is a simple average taken over an interval of time. This method automatically recomputes the average for each new time period and deletes the data from the oldest time period. All time periods are equally important.[18] This method derives a forecast by using the last computed value or by projecting a moving average trend line.[19]

Exponential smoothing is similar to a moving average but is more responsive to change because it gives a greater weight to the most recent period.[20]

The weighting factor, which is the smoothing constant, gives a greater influence to the more recent periods. This characteristic makes the forecasts of this model more reflective of changes in demand.[21]

Trend extrapolation is a regression method that mathematically fits a line or curve to historical data. The user predicts the future by projecting the mathematically derived line or curve beyond the historical set of data points.[22] This method assumes that the forces influencing the line or curve will remain consistent into the future.[23]

Time series decomposition takes the trend extrapolation a step further by imposing predicted trend, seasonal, and cyclical influences upon the forecast. The best curve or representative line, based on the data points, is the result of the least squares regression method. Decomposition allows for the development and inclusion of causal relations in the development of forecasts.[24]

The autoregressive moving average is among the most sophisticated time series methods. This method uses a regression relationship based on past time series values to predict future time series values. A constant correction and fine tuning process occurs when using this method. This method also allows the manager

to add his judgements or qualitative analysis to the forecast development method.[25]

Forecasting models incorporate these quantitative techniques and attempt to represent, through a mathematical abstraction, real-world phenomena to gain a glimpse of the future. Mathematical forecasting models provide managers with information they can use to make decisions and render a level of confidence to those decisions. These mathematical models release the human mind from the tedious and repetitious use of formulas and calculations. The mind of the manager is then free to explore possibilities, to make judgements, and to apply expertise and experience in decision making.[26] However, there are two basic caveats to using any model. The first caveat is, models are totally dependent on correct logic and input; and the second is, models are not a substitute for good judgement.[27]

The quantitative analysis process using models consists of five discrete steps.[28] The first step is problem definition. This is the most important step in the process and must be done in terms of objectives and constraints. After defining the problem in these terms, the next step is model development. These quantitative models simplify the abstractions of a

real-world situation and act as predictive tools that yield mathematical results. The models express the mathematical relationship between the stated variables. After developing the model, the next step is to collect, format, and input the required uncontrollable values. Model solution occurs next. This entails manipulating the model to derive the optimal solution to the problem. An important part of this step is the validation of the model to ensure its accuracy. The last step involves the production of the managerial report based on the model's solution. The receiving manager uses the report as one of the inputs to his decision making process. He constantly reviews the value and accuracy of the model to determine if it needs further expansion or refinement.[29]

Typical decision models used for inventory systems are probabilistic demand models.[30] Managers use probabilistic demand models whenever the demand for an item is not precisely known because probabilities can provide a degree of certainty. Stochastic models are the best to use when uncontrollable inputs such as demand for parts are uncertain and subject to variation. The Stochastic model negotiates the uncertainty (of demand in this case) by using probability and statistics.[31] The model then uses

the Poisson distribution to further remove the veil of uncertainty. This distribution provides a means to determine the probability of occurrence of these uncontrollable demands over a specified time interval.[32]

Forecasting models aid in determining inventory stockage composition and levels. A model of this type in the commercial sector will be of a Stochastic type that uses a compound Poisson demand. The model design incorporates several considerations. These considerations are failure rates, desired level of performance (readiness rates in a military application), customer equipment densities, repair-cycle times, order and ship times, reorder quantities, cost constraints, and physical capacity constraints (number of lines authorized for stockage).[33]

The linkage between the forecasting technique, the accuracy of the forecast, and inventory management is critical. The forecast is the key to the inventory management system. By providing the most accurate picture of the future, the forecast serves as the basis for decision making. The accuracy of the forecast increases with the sophistication of the method. As the accuracy of the forecast increases, so does its

benefit to the inventory management system. On the other hand, using an inaccurate method such as the mechanical approach, despite its simplicity and ease of understanding, will result in a poor forecast of demand.[34]

The other integral part of inventory management is the ordering and distribution system. Supplies must flow through the logistics system to meet the customer's need. The ordering and distribution system physically accomplishes this flow.

## ORDERING AND DISTRIBUTION SYSTEMS

To a customer, a responsive supply system is one that provides the necessary item in a timely manner. To achieve responsiveness, the ordering and distribution system must anticipate the customer's demands. Such a system initiates the movement of the item in anticipation of demand so the item is on hand when the customer needs it. Three approaches to meeting customer needs are the independent ordering system, the base stock plan, and Distribution Requirements Planning.[35]

In an independent ordering system, each unit operates independently and develops its own forecast. An independent ordering system assumes that what one unit orders is unrelated to what another units

orders.[36] The unit tabulates demands to determine its own stockage composition and levels, computes reorder points, and requests replenishment.

This is a bottom-driven system where changes in response to demand lag behind actual demand, fluctuations in demand at unit level surge unpredictably to higher levels, and units make decisions based on their own limited information. This myopia results in the system's instability and inability to make accurate forecasts. The PLL and ASL system is an example of the independent ordering system.[37]

The second ordering and distribution system is the base stock plan. Under this system each unit establishes a communications link with the distribution system and provides current demand information to a central headquarters on a regular, usually daily, basis. This information flow is independent of the replenishment order submissions. Based on the information collected on demands, the distribution system ships items in anticipation of orders. Models provide forecasts which allow stockage and distribution decisions in anticipation of demand. The base stock plan does not consider the capabilities and capacities of the distribution and inventory systems.[38]

The third, and most sophisticated, system of predicting stockage needs is Distribution Requirements Planning. This system synchronizes the inventory requirements by time period with the aggregate demand forecast and coordinates the unit replenishment schedules. Distribution Requirements Planning considers the demand forecast along with the capacity and capability of the distribution and inventory system. The forecast is one of several inputs into the model that produces a master inventory and distribution schedule.[39]

Through anticipation, this system synchronizes the inventory and distribution systems. This synchronization allows the delivery of stocks to coincide with the occurrence of demand, efficient use of the distribution and inventory systems, reduction of safety level stocks, and avoidance of shortages.[40]

There are many operations research alternatives available to improve the efficiency of the heavy division's repair parts management system. The way to this improvement is inventory management. The means are accurate forecasting and the utilization of a suitable ordering and distribution system. The operations research means available will provide for better customer service, reduced inventories, and

efficiency of the supply and distribution systems.

The heavy division can incorporate these alternative means into the inventory management systems of the DMMC. The DMMC is capable of performing this mission because it has experienced and knowledgeable personnel equipped with the necessary communications and ADP support systems. The private sector practices this concept of centralized management, which matches ways and means to achieve desired ends.

## IV. PRIVATE SECTOR[1]

One of the desired ends for the private sector is profitability. Private sector firms achieve profitability by taking proven concepts and turning them into effective and efficient business practices. In the course of my research, I conducted an informal survey of private sector practices in the retail supply of repair parts. The purpose was to gain an appreciation for the practices of the private sector and to determine if the Army could use these practices to improve the repair parts management system.

The survey was in no way exhaustive and did not attempt to capture the total business practices of the companies surveyed. As intended, the survey was an

informal glimpse at two private sector firms in a business related to the subject of this monograph. The companies surveyed were NAPA-Genuine Auto Parts and Western Auto. The survey was in the form of personal interviews conducted on 13 September 1991. The areas of focus were the general concept of operations, methods for inventory forecasting, and distribution policies and procedures.

Both NAPA and Western Auto use centralized decision making and decentralized execution as their general concept of operations. The approach they use is a variation of the Distribution Requirements Planning system introduced in section III. Decision making and guidance flow from the top down. However, there is a bottom-up flow of information that management uses to formulate its guidance. Through this system of centralized decision making, both companies conduct detailed information gathering, modeling, and analysis.

Both companies electronically link every retail outlet to the corporate headquarters and the distribution centers. This communications link is absolutely critical to their day-to-day operations. This electronic link between all three nodes ensures the constant flow of information to update databases and to make and issue orders. All orders go from the

retailers to the corporate headquarters which then directs the distribution center to make the delivery to the retailers. The central database at the corporate headquarters captures all demand information daily, whether that demand is filled or not. This broad measure of current demand is the foundation for decisions.

While both companies use centralized decision making, their decentralized execution provides flexibility to their operations. At NAPA the distribution centers and the retailers have the authority to adjust their inventories based on their judgement. The criteria for these decisions vary; they range from changes in local demographics to weather. The overriding intent is to achieve responsiveness and flexibility in meeting the needs of the customer.

Western Auto operates under the same intent but delegates the authority to change inventory only to the retailers. The Western Auto distribution centers have no authority to change the stockage of their inventories; they perform a purely warehousing and distribution function.

The second area I focused on was inventory forecasting. Both companies rely heavily on computer-supported models in their forecasting

functions. As previously mentioned, the corporate headquarters are the focal point for receiving all demand information and producing forecasts. The concept is that forecasts of local demands are more accurate if based on nationwide demand history and usage factors. These models produce forecasts based on demand history, input from manufacturers, current demand, regional and seasonal requirements, and human interface. The companies use these forecasts to anticipate future demand and place items into inventory at regional distribution centers and retail outlets. These forecasts enable both companies to better respond to the needs of their customers and maximize their inventory and distribution systems. As a result, they lose fewer sales and achieve economies of scale in both procurement and transportation.

The third area focused on was distribution policy and procedures. Similarities and differences exist between the two companies in this area. The first similarity is both companies possess nationwide asset visibility and accessibility of stocks. Each retail outlet has real-time visibility of stocks at the national distribution centers. If a required item was in stock, the retail outlet could request immediate shipment from the national distribution center.

The second similarity is the thorough integration of the supply and distribution systems. While in transit, items are still part of the supply system; the supply system also moves or positions items in anticipation of demand. The distribution system not only moves the items but is also part of the inventory operation.

The differences between the two companies are in the number of national distribution centers and the related delivery time for requested items. NAPA operates seventy national distribution centers, and their standard for delivery of requested items is one day. This responsiveness results from the close proximity of distribution centers to retailers, the depth of stockage at the distribution centers, and the accurate forecasting of demand.

Western Auto operates four national distribution centers with the same depth of stockage and accurate forecasting of demand as NAPA. The Western Auto standard for delivery of requested items is one week. This difference in time standard is necessary to accommodate the fewer distribution centers and greater distances between the distribution centers and retailers.

Two other noteworthy practices of both companies were the high standard for customer satisfaction and the use of technology. The customer satisfaction goal of the two companies is 95%, and the standard for a zero balance with dues-out or backorder is 1%. As pointed out earlier, the only difference is the time standard for meeting the demand.

Both NAPA and Western Auto make maximum use of technology to enhance their operations. In addition to the areas of communications and forecasting that have already been presented, both companies exploit modern technology in bookkeeping, accounting, and inventory functions. For instance, they use barcode technology to save time, increase accuracy, and help maintain asset visibility in inventory and distribution functions.

There are several practices that both companies follow which contribute to their success and are worthy of emulation by the Army. Common to both companies are a top-down (centralized) approach to decision making and forecasting; an inventory management system based on detailed forecasts; use of sophisticated computer-supported models for forecasting; an integrated supply and distribution system; high performance standards for customer satisfaction; and

exploitation of technology to produce an interconnected system for the flow of information, orders, and issues.

There are obvious differences in the operating environments of the Army and these companies. However, these differences should not prevent the Army from studying these sound business practices. The success of NAPA and Western Auto in a highly competitive environment justifies further study. Perhaps the incorporation of these practices can improve the generation and sustainment of combat power in the heavy division.

## V. ANALYSIS, EVALUATION, AND CONCLUSIONS

The current maintenance and repair parts management systems in the heavy division adhere to the maintenance concepts of "fix forward" and "remove and replace." This system of maintenance is extremely dependent on the availability of repair parts. A complex system of policies and procedures balances the need for repair parts against the fiscal and physical constraints imposed upon the supply and maintenance systems.

The concept for the repair parts management system is a bottom-up approach. The PLL section is the foundation of the repair parts system. The stockage

decisions of the unit PLL clerk affect the decisions made at the higher levels of support in the division. The history of demands from the unit PLLs determines the stockage of the ASL. Therefore, the division's ability to generate combat power rests on the assumption that the PLL is an accurate forecast of future demand.

As noted in section II of this monograph, the effectiveness of the repair parts system has been the subject of numerous studies. Consistently, these studies reiterate the inefficiency of the current bottom-driven repair parts system. The most glaring shortfall is reliance on the PLL to be an accurate forecast of future demand. As noted in the 1981 DCSLOG report, the PLL does not provide an accurate forecast and is the basic weakness of the repair parts system. Due to the bottom-up approach, this weakness then negatively affects the efficiency and effectiveness of the entire system.

The most recent criticisms come from the Desert Storm Special Study Group's report. The observations in the report reinforced and highlighted the previously identified shortfalls in the repair parts management system.

Operations research alternatives and the practices of the private sector provide ways and means to improve the PLL and ASL system. The operations research approach to decision making can significantly improve the inventory management, forecasting, and ordering and distribution systems.

Operations research techniques can help develop an inventory management system that achieves a balance between customer service and an efficient operation with a small inventory. The key to achieve this balance is to accurately forecast demand.

The Army must develop a forecasting model to improve the performance of the repair parts management system. An accurate forecast can be achieved by following the principles and essential steps of forecasting. By integrating the qualitative and quantitative approaches to forecasting, the Army can develop a probabilistic decision model that accurately represents the environment, establishes casual relationships, and forecasts demand.

Operations research is also useful in the area of ordering and distribution. A particularly useful system to emulate in this regard is Distribution Requirements Planning. The heavy division needs a system that ships items in anticipation of demand and

fully integrates inventory and distribution capabilities.

The Army can benefit by incorporating the practices of the private sector. The concepts, methods, policies, and procedures are all products of extensive study, research, development, testing, and experience.

NAPA-Genuine Auto Parts and Western Auto are two successful companies in a highly competitive market environment. Like every business, their success is a direct result of how efficiently and effectively they satisfy the demands of their customers. Both companies validate their general concept of operations, methods of inventory forecasting, and distribution policies and procedures on a daily basis.

The lessons learned from the practices of these two companies are the advantages of using a centralized, top-down, approach to decision making, using good forecasting techniques to anticipate rather than react to demand, using computer-supported modeling to develop forecasts, exploiting modern technology to link together their operations with interconnected communications and data processing networks, and fully integrating the supply and distribution systems.

The current repair parts management system does not meet the needs of the heavy division. The Army should

redesign the system so that it efficiently and effectively supports the generation and sustainment of combat power in the heavy division. Ideally, the redesigned system should improve the level of customer satisfaction, minimize the size of the inventory, and increase efficiency.

The operations research alternatives and private sector practices provide a solid basis to develop a redesigned repair parts management system. As a minimum, the Army can adopt a centralized, top-down approach to repair parts management in the heavy division and centralize the forecasting and decision making functions at the DMMC. The DMMC has the communication link, ADP support, database, and personnel with the requisite knowledge and expertise to perform the management functions.

The DMMC could use the division's aggregate demand history from the DS4 and usage profiles as a basis for forecasting. These forecasts would be more precise statistically as compared to the collection of individual PLL forecasts.[1]

The DMMC can modify the DS4 to use its database for the modeling. By collecting and combining the usage profiles and the aggregated demand as a basis for forecasts, the DS4 can produce a predictive versus a

reactive PLL. For example, if the model predicts that a HMMWV's fan belt will fail after 30,000 miles, it will recommend the addition of fan belts to the PLLs of those units whose HMMWVs are approaching 30,000 miles. The current system would place the fan belts into the PLL only after a number have failed.

The DMMC can determine the composition of the PLLs and ASL based on the model's forecast. The responsibility for the formulation of the PLLs and ASL shifts from the unit PLL clerk to the DMMC. The unit PLL clerk will then be responsible to maintain guardianship of the PLL, report demands and vehicle utilization to the DMMC, and identify parts that need replenishment.

While these changes would be transparent to the customer units, the concept of operation would be radically different. The new concept would correlate usage profiles with the demand history and establish causal relationships. The model would then use this information to anticipate the demand for repair parts.

The Army can implement this concept with no increase of personnel, no additional equipment, and no organizational changes. The changes required are modification of the governing policies and procedures and addition of a new forecasting model to the DS4.

A predictive, rather than reactive, Army system could more efficiently procure, stock, distribute, and supply repair parts. In every one of these functions, a predictive system allows for the most efficient utilization of resources. A benefit of such a predictive system is the reduction of safety levels. Units would not have to maintain large inventories to compensate for long order and ship times if the integrated supply and distribution systems are constantly moving items to customers in anticipation of demand.

The most important benefit of this new concept is achieving the goal of the supply and maintenance systems, i.e., the generation and sustainment of combat power. The heavy division and the Army do not have to suffer from idle equipment waiting for parts, lost training opportunities, and wasted warehousing and transport resources used to store and move tons of excess parts.

## VI. SUMMARY AND RECOMMENDATIONS

The focus of this monograph has been the management of repair parts in the heavy division. The intent was to find ways to improve the sustainment system's

ability to support the generation of combat power at the decisive place and time. That capability will only derive from a sustainment system that anticipates, rather than reacts to, the needs of the combat unit.

The conclusions of this monograph result from the study and evaluation of the problems and procedures of current repair parts management system and the exploration of operations research and private sector alternatives. The maintenance concepts are sound but the bottom-driven supply management system does not support the generation and sustainment of combat power. The supply management system for repair parts is reactive rather than proactive. There is currently no capability to accurately forecast and anticipate requirements through the establishment of causal relationships between demand history and usage profiles. However, the Army can acquire this capability by adopting operations research alternatives and private sector practices.

More specifically, the Army can adopt the private sector's top-down approach to repair parts management. The decision making authority and management could reside at the DMMC where the requisite personnel (with the knowledge, experience, and training), communications, and ADP resources currently exist.

The result of these changes will be a simplified and more efficient system. The PLL clerk will be responsible for maintaining stocks, tabulating demands and vehicle utilization, and identifying parts that require replenishment. The DMMC will determine and direct the composition of the PLLs and ASL.

The Army can further pursue using operations research alternatives to develop inventory, forecasting, and distribution models and systems to produce a anticipatory versus reactionary system. Based on these models the supply and maintenance systems can take the initiative by providing support in anticipation of demand rather than waiting to react to a request.

This centralization of management also enables the more efficient integration of the supply and distribution systems. This integration in turn allows for the reduction of inventory levels and the increased mobility of units. Heavy divisions can throw off the yoke that straps them to the metal mountains of useless repair parts.

These recommended changes will help conserve scarce resources, increase customer satisfaction, and enhance the generation and sustainment of combat power. For every one percent increase in the efficiency of a

heavy division's ASL, it makes better use of $315,968. Perhaps it may even be possible to raise the customer satisfaction standard for the ASL from its objective of 75% closer to the 95% of the private sector.

A heavy division can obtain these benefits with little cost and disruption to the current support system. There are no additional requirements for personnel, equipment, or organizational changes. The only required actions are to provide the recommended forecasting model to the DMMC and develop and implement the necessary policy and procedural changes. The changes would be transparent to the customer units. The only apparent difference would be the increased responsiveness of the supply system.

To fight and win, the heavy division must have the means to generate and sustain combat power at the decisive place and time. Such a means is an efficient and effective repair parts management system. Failure to provide this means is unforgivable given the tempo and intensity of the modern battlefield.

# APPENDIX A

## GLOSSARY

**Dues-out or backorder**

That portion of requested stock not immediately available for issue and not passed to another source of supply for action. Record of obligation to fill the backorder is known synonymously as a backorder or due-out.

**Materiel**

Property necessary to equip, maintain, operate, and support military activities. May be used either for administrative or combat purposes.

**Order Ship Time**

The interval of time between the submission of replenishment requests until the stock receipt is posted to the account.

**Operations Research**

The body of knowledge and methodology which uses a scientific and quantitative approach to decision-making.

**Qualitative Forecasts**

Forecasts based on human judgement and experience.

**Quantitative Forecasts**

Forecasts based on statistical techniques which use historical or correlational analysis.

**Poisson Probability Distribution**

The probability distribution for a discrete random variable. It is used to compute the probability of x occurences of an event over a specified interval.

**Probabilistic Demand**

Situations in which demand for the inventory item is not known exactly and probabilities must be used to describe the demand.

**Retail Supply**

Generally oriented toward attaining maximum operational readiness of support units, and therefore is based on demand or item essentiality. Level of supply below the wholesale level.

**Safety Level**

Quantity of stock intended to permit continued support in the event of minor interuption of stockage replenishment or unpredictable fluctuation in demand rate, or both.

**Stochastic Model**

A model where at least one uncontrollable input is uncertain and subject to variation.

## APPENDIX B

## ABBREVIATIONS

| | |
|---|---|
| **AMSAA** | Army Materiel Systems Analysis Activity |
| **ASL** | Authorized Stockage List |
| **DCSLOG** | US Army Deputy Chief of Staff for Logistics |
| **DMMC** | Division Materiel Management Center |
| **DS** | Direct Support |
| **DS4** | Direct Support Unit Standard Supply System |
| **DSU** | Direct Support Unit |
| **HMMWV** | High Mobility Multi-Purpose Wheeeled Vehicle |
| **MPL** | Mandatory Parts List |
| **MRE** | Meal, Ready to Eat |
| **MRSA** | Materiel Readiness Support Activity |
| **PLL** | Prescribed Load List |

# ENDNOTES

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## Section IV Private Sector

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